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The masquerade ball of the CEOs and the mask of excessive risk☆

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ABSTRACT

Two well-known explanations for excessive risk taking by CEOs are limited liability, which protects them from the downward risks of their project choices, and convex compensation schemes that encourage risk taking. This paper provides a career-concerns-based motive for why a CEO might choose an excessively risky project even in the absence of them. A CEO of unknown managerial ability could be fired if she is found to be below average. To limit this layoff risk, she tries to conceal her true type by choosing excessively risky projects. Excessive risk taking makes the firm unable to determine if a poor outcome resulted from incompetency or negative risk realization.

1. Introduction

Why might CEOs take excessive risks in overseeing their firms? Two well-known explanations are limited liability, which provides insurance to CEOs against the downward risks of their project choice, and compensation schemes that encourage risk taking (*e.g.*, convex compensation schemes). In this paper, we provide an additional reason for why there might be excessive risk taking in the market even in the absence of limited liability and compensation schemes that encourage risk taking. We argue that a CEO's career concerns regarding potential termination give her incentive to try to improve the market's expectation about her managerial ability. We show that a CEO can achieve this goal by choosing excessively risky projects and that, under certain conditions, explicit incentives provided by optimal linear compensation contracts cannot prevent her from choosing such projects. Hence, our theory is based on managerial risk appetite erected by career concerns and shows that regulations restricting convex compensation schemes may not be the most effective to wipe out excessive risk from the market. In fact, in contrast to the movements toward linear contracts, especially in the US due to the injection of public funds, we find that while linear contracts cannot always guarantee optimal risk taking, bonus contracts or linear contracts with severance payment options result in optimally risky projects to be chosen by the CEOs.

We undertake our analysis in a simple principal–agent framework in which a (risk-neutral) firm operates for two periods. We initially assume that there are two types of (risk-neutral) CEOs, high and low ability, who are found equally in the population. Neither the firm nor the CEO knows the ability of the CEO in the beginning. The CEO chooses the project to be undertaken by the firm from a pool of investment projects. Projects differ in their probabilities of failure and potential returns, and there is a high risk-high return/low risk-low return technology in the sense that a project with a higher probability of failure has a higher return in the good state and higher loss in the bad state. Among the potential projects, there are excessively risky ones with lower expected returns and higher probabilities of failure, some even with negative net present values which are in fact chosen in equilibrium. In the end, the project can succeed or fail. Because of regulations, the firm may have to employ an (optimal) linear compensation contract that allows for any combination of fixed wages and stocks. Therefore, there is no convex compensation scheme that increases risk appetite, and there is no limited liability since the CEO incurs a loss if the output realization is negative.

The firm hires a CEO of unknown ability from the managerial pool and *ex ante* expects her ability to be average in the population. If it finds out that her ability is below average at the end of the first period, it fires her and hires a new CEO, whose ability is expected to be average. This layoff risk is the source of the CEO's career concerns and it gives her

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incentive to influence (or in fact improve) the market's expectation about her ability.[1] Suppose, for the moment, that the CEO knows her ability and it is low. In such as case, she can simply “gamble” by choosing an excessively risky project. When the good state realizes, the firm cannot be sure if the observed output is produced by a low- or high-ability CEO. However, it has to statistically conclude that the CEO is more likely to be a high-ability one in the bad state as the probability of success is lower with excessively risky projects. When the bad state realizes, the firm infers the CEO's ability and fires her. But, if she did not choose an excessively risky project, she would be fired in any output realization. This means that she can lower her probability of being fired by choosing an excessively risky project.

More importantly, a CEO who does not know her ability also has the same motivation. Because she takes into account the possibility that her ability might be low, she tries to prevent the firm from perfectly inferring her ability. In our model, she can do so by choosing the excessively risky project with which the good-state output of a low-ability CEO coincides with the bad-state output of a high-ability one. When the firm observes this “overlapped” output, it cannot know exactly which ability type in fact produced this output. However, because the probability of failure is higher with an excessively risky project, the firm believes that the observed output is more likely to be the bad-state realization of a high-ability CEO than the good-state realization of a low-ability one. Consequently, the firm's expectation about the CEO's ability will be higher than average even though each type is *ex ante* equally likely, which means that the CEO is not fired in such an output realization. In fact, by following this strategy, she is fired only if she turns out to be a low-ability CEO in the bad state.

We show that the strategy of overlapping the outputs (by choosing an excessively risky project) minimizes the probability of being fired when the difference between the two possible abilities is neither too high nor too low. One can interpret this situation as a business sector where both innate ability and project choice have substantial impact on the final outcome. Yet, minimizing the probability of being fired is not automatically an equilibrium even in that parameter range. It is so when the CEO's compensation benefit she derives by choosing the optimally risky project in the first period is dominated in expected payoff by the career benefit she derives by choosing an excessively risky project to minimize her probability of being fired. In such a case, excessively risky projects are undertaken in equilibrium under the optimal linear compensation contract that pays any combination of fixed wage and stocks. This contributes to the ongoing debate about the movement toward linear contracts in the regulation of compensation structures to prevent excessive risk taking. As opposed to these movements, in our setting, the optimally risky project is implemented with bonus contracts or linear contracts with severance payment options.

Policy debates emphasize the CEOs' *responsibility* in the inefficiently high levels of risk taken by firms. Yet, when a linear contract is used, we show that, in addition to cases in which the firm *involuntarily* allows the CEO to choose excessively risky projects, there are also cases in which it *voluntarily* allows her to do so. In the former case, the firm allows the CEO to choose an excessively risky project because no permitted compensation contract can have her choose the optimally risky project. However, in the latter case, although having the CEO choose the optimally risky project could be profitable for the firm, letting her choose an excessively risky project is even more profitable. This is inefficient from the point of view of society, as the return from an excessively risky project has negative net present value. Thus, shareholders sometimes share the responsibility of inefficient levels of risk in the firm.

Our results hold even when CEOs are risk averse. We further show that excessively risky projects are undertaken even when there is a continuum of ability types. This case also illustrates an inverse U-shaped relationship between the unobserved ability of the CEO and her layoff risk. Among below-average CEOs, a higher-ability one is more likely to be fired than a lower-ability one, while above-average CEOs face no layoff risk. Our explanation for excessive risk taking is not limited-liability based, as there is no limited liability for the CEO in the model. As a matter of fact, incorporating limited liability into our setting would increase CEOs' risk appetite.

The mechanism we describe in this paper is relevant to any sector where both innate ability of the CEO and her project choice are sufficiently important in project outcomes (which is the case analyzed in Lemma 2).[2] In such a setting, there could be a trade-off between innate ability and project choice and, because the ability is fixed, depending on the economic and institutional environment, the CEO might find it optimal to distort her project choice to hide her true ability as much as possible. Obviously, the occurrence of this situation is sector specific. Although the banking industry, or the financial sector in general, is an obvious example in which such incentives may be present, the mechanism we present is not limited to these sectors.

We now explain how our paper relates to prior work. There is a large body of literature that analyzes how career concerns affect the behavior of agents. Holmstrom (1982) finds that since investing in a project carries the risk of one's ability being discovered, a risk-averse manager behaves overly conservatively by not investing in risky projects at all. Holmstrom and Ricart i Costa (1986) elaborate on this idea further and show that conservatism can be fixed if the shareholders can offer a downward rigid wage. Building on Holmstrom's findings, the literature that followed has focused on *managerial conservatism* in a broad sense (see, *e.g.*, Hirshleifer and Thakor, 1992; Zwiebel, 1995, and Gormley and Matsa, forthcoming). Contrary to this literature, we show that career concerns may lead managers to choose excessively risky projects, even when they are risk averse.

Our paper is linked to the recent literature on the relationship between CEO turnover and their risk taking. For example, Bushman et al. (2010) analyze whether firm-specific or systematic risk increases turnover in a setting where risk is exogenous. Instead, we look at the implications of CEO turnover for risk taking when both the risk choice of the CEO and the turnover decision of the firm are endogenous. Hu et al. (2011) study risk-shifting effects of a manager's employment risk and find a U-shaped relationship between the manager's risk choice and her prior relative performance among her peers. We find a similar inverse U-shaped relationship between the CEO's ability and her layoff risk. In our setting, while above-average CEOs face no layoff risk, among below-average ones, lower-ability CEOs have lower layoff risk than do higher-ability ones. Using a continuous-time model of the dynamics of private equity funds, Buchner and Wagner (2015) show the relevance of career concerns for risk taking by fund managers. In particular, having call options leads fund managers to take excessive risk unless they are concerned about being hired again. In contrast to prior studies in this literature, we provide a unified framework where managerial turnover, risk taking, and compensation contracts are determined endogenously.

Our paper is also related to the literature analyzing types of statistical bias that managers try to add to the market's inference about their unknown abilities. In Scharfstein and Stein (1990), the motivation of the manager is to minimize reputational risk by following the crowd. In Hermalin (1993), in order to avoid actions that are informative about her abilities, the risk-averse manager decreases the informativeness of output by choosing projects with higher variance. In Milbourn et al. (2001), in order to alter the market's assessment of her ability, the manager distorts the probabilities of reputational states that are

[1] The firing rule and its career-concerns implications are practically relevant. As Wagner (2002) and Sheng et al. (2014) point out, many portfolio managers follow some benchmark indices in their investment strategies.

[2] Obviously, in some other sectors, either the impact of innate ability or that of project choice could be negligible and thus excessive risk taking due to career concerns does not arise. The cases analyzed in Lemmas 1 and 3 could be interpreted to represent these situations.

observed and unobserved by overly investigating potential projects. In contrast to these papers, we provide a novel mechanism where managers can improve the market's expectation on their managerial abilities by their project choices; even they share the same information with the market.

The paper is organized as follows. Section 2 outlines the model. Section 3 makes the analysis. Section 4 extends the two-type analysis to a continuum of types. Section 5 concludes. An (online) appendix contains further details and proofs.

2. The model

We consider a unit mass of risk-neutral CEOs, each of whom may potentially be employed by a risk-neutral firm. CEOs differ in their innate *managerial ability*, which is represented by θ_i, where $i=\{H,L\}$ and $\theta_L<\theta_H$. A CEO with a managerial ability of θ_L (θ_H) is called a *low-ability* (*high-ability*) *CEO*. Each type is equally likely in the population, and thus the average ability of a CEO is $\bar{\theta} := (\theta_H+\theta_L)/2$. No one, including the CEO herself, knows the type of a CEO, but the distribution of types in the population is common knowledge. Thus, all parties, including the CEO herself, hold identical prior beliefs over her managerial ability. Given her managerial ability, she chooses her "managerial action," or the project to be undertaken by the firm. Projects differ in their probability of failure, $r\in[0,1]$, which is privately known by the CEO.[3] There is no borrowing and lending, and neither the firm nor the CEOs discount future payoffs.

The firm operates for two periods, $t=\{1,2\}$. The output of the firm in any period is determined by both the managerial ability of, and the project choice by, its current CEO. If a CEO of managerial ability θ_i chooses a project with probability of failure r_t in period t, then the *realized* output of the firm, $y_t(\theta_i,r_t)$, is

$$y_t(\theta_i,r_t)=\begin{cases}\theta_i-f(r_t) & \text{with probability } r_t\\ \theta_i+f(r_t) & \text{with probability } 1-r_t,\end{cases} \quad (1)$$

where $f(r_t)$ is an increasing, concave, and twice-continuously differentiable *managerial action-return function* with $f(0)\geq 0$.[4] This specification models managerial ability as "alpha," *i.e.*, the ability to generate high returns even without incurring high risks (see Acharya et al., 2012).[5]

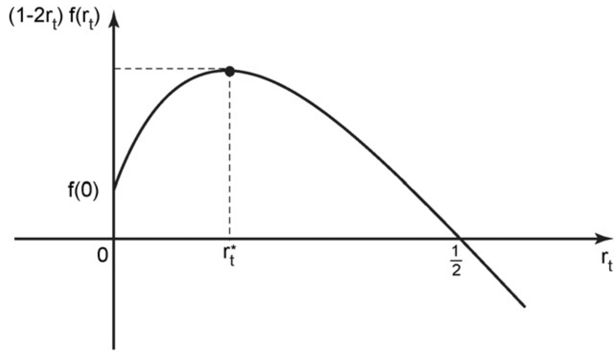

Fig. 1. Expected return from managerial action.

The managerial action-return function is increasing in r_t to capture the idea that assets with higher default risks have also higher risk premiums. We keep this technological specification fixed throughout the paper. The reservation payoff of a CEO per period is $\underline{u}$, which satisfies $0<\underline{u}\leq\theta_L$, as long as her ability is not certain to be below $\bar{\theta}$. Thus, the firm may find it profitable to hire a CEO by paying, at least, her reservation payoff. Following Bushman et al. (2010), we assume that the reservation payoff of a CEO whose ability is inferred to be below $\bar{\theta}$ immediately becomes zero. This is mainly because no one would prefer to hire her over hiring another CEO from the market whose ability is expected to be $\bar{\theta}$.[6]

The *expected* output of the firm in period t, $E[y_t]$, is

$$E[y_t(\theta_i,r_t)]=\theta_i+(1-2r_t)f(r_t)\quad \forall t=\{1,2\},\forall i=\{H,L\}. \quad (2)$$

Although we choose a simple managerial action-return function, the mechanism we focus on is general. Given the managerial ability, we interpret this technology as a collection of investment projects with different realized returns and probabilities of failure pairs resulting in different expected values for each project.[7] Each combination results in different expected values for each project. This technological specification makes good sense in many real-life situations. For example, in credit relationships, creditors usually require higher interest rates for loans that have a higher probability of default. Firms can make investments that either succeed or fail. Entrepreneurs can make choices between safer and riskier projects that either succeed or fail. With our specification, an increase in the probability of failure increases the output in the good state and the loss in the bad state. Hence, as shown in Fig. 1, there is an *optimally risky project* with $r_t^*<1$ that maximizes the expected output of the firm.

We now define what we mean by an *excessively risky project*.

Definition 1. (Excessively risky project) *An excessively risky project has a lower expected return but higher probability of failure than the optimally risky project.*

An excessively risky project is second-order stochastically dominated. However, what we find will be even stronger than finding that a dominated project was chosen. Following Petersen and Rajan (1995)

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[3] In Holmstrom (1982), Holmstrom and Ricart i Costa (1986), and Hermalin (1993), observability of project choice and risk aversion are crucial to the obtained results. In our setting, we do not need to assume that the project choice is unobservable as long as CEOs do not know their abilities because the market correctly predicts this anyway. However, this assumption would be crucial under an asymmetric information case in which CEOs privately know their abilities and each type chooses projects with different probabilities of failure in equilibrium. We have also shown under an asymmetric information structure that a low-ability CEO, who privately knows her type, would choose an excessively risky project in some parameter ranges. The proof is available upon request.

[4] One can generalize the analysis by having $E[y_t(\theta_i,r_t)]=g(\theta_i)+(1\text{-}2r_t)f(r_t)$, and this does not change the qualitative results as long as $g(\theta_i)$ is an increasing function. Our results are independent of the fraction of types in the population as long as the population is not entirely composed of just one type. Moreover, our results hold unless both the managerial action-return function is convex and the state realizations are asymmetric in favor of the good state. In that sense, we could set the contribution of the project choice to the project outcome to be zero, rather than $-f(r_t)$, in the case of failure. Such a specification could represent the payoff function of deposit-taking institutions. In that interpretation, r_t is the borrowers' default risk. A borrower pays zero in the default case and an interest payment of $f(r_t)$ in the non-default case. An increasing $f(r_t)$ function implies that the deposit-taking institution requires higher interest from those who have higher default risk. However, this would make the model less general simply because in that case all projects will be nonnegative valued. Our specification is more general.

[5] Our technological specification is consistent with the evidence showing that not only the managerial ability (Falato et al., 2015) but also the managerial style (in our case the project choice) (Bertrand and Schoar, 2003) matter in the firm. The assumption that θ_i enters the production technology linearly is quite common in the literature and it is assumed only for simplicity.

[6] One could alternatively interpret $\underline{u}$ as a private non-pecuniary benefit of control of the firm in the second period.

[7] For our results, we do need the project outcomes of some CEO types to coincide. This can be achieved by employing various specifications. In any structure that can work, the firm is sometimes prevented from identifying the CEO's type, which she achieves by employing excessively risky projects. In a large number of papers, the choice is only between a riskless and a risky project that can either succeed or fail. The insight we have in our paper remains true even with two-asset specifications (the proof is available upon request). Our managerial action-return function is a generalization of such specifications to many projects.

and Palomino and Prat (2003), we allow for negative expected values for projects and show that in the equilibrium, the expected return from managerial action, $(1-2r_t)f(r_t)$, is negative valued for the excessively risky project chosen. Therefore, the CEO chooses a project with a too high probability of failure that it results in negative expected return from the contribution of managerial action to the output. Palomino and Prat (2003) point out that in a typical textbook, only the efficient frontier (increasing part of Fig. 1 in our setting) is depicted because a risk-neutral or risk-averse investor does not choose such dominated portfolios. However, a manager motivated with "wrong" incentives might want to choose such portfolios, as Palomino and Prat (2003), as well as our paper, show.

According to Markowitz portfolio selection, such dominated portfolios exist in financial markets. For example, when short sales are allowed, all individual assets lie on the right-hand side of the efficient frontier and are dominated by well-diversified portfolios on the efficient frontier (Bodie et al., 2009, pg. 210). In our framework, misalignment of incentives between the firm and the CEO leads the latter to choose such dominated assets even though it has lower expected return and higher risk than the assets on the efficient frontier. We should note that our results are not an artifact of having the possibility of negative-valued projects. We would get similar results even if we allowed for only positive-valued projects in the model because a relatively worse performer will still face the risk of dismissal and, thus, incentives leading to our results remain the same.

Contracting between the firm and the CEO is fairly simple. We assume that the firm is not able to offer two-period contracts.[8] Thus, in each period, the firm offers the CEO an individually rational and incentive-compatible compensation contract. The realized compensation of the CEO in period t is represented by w_t. Because the CEO's managerial ability is unobserved, the first-period output of the firm is a predictor of her future productivity. Hence, her layoff risk in the second period is influenced by the realized output in the first period, which is influenced by her project choice. This creates the CEO's career concern in our setting and results in a misalignment between her and the firm's preferences. The CEO maximizes her two-period expected compensation by choosing a project in each period, while the firm engages in period-by-period maximization and makes a firing decision in between the two periods, if necessary, upon updating its beliefs based on the first-period output realization.

The sequence of events is as follows. At the beginning of the first period, the firm offers a take-it-or-leave-it kind of contract to a CEO with a reservation payoff of $\underline{u}$. If she accepts the contract, she chooses a project, whose probability of failure is represented by r_1. Then, the first-period output y_1 is realized. The firm pays w_1 to the CEO, updates its beliefs about her managerial ability based on the realized output, and decides whether to fire her. A fired CEO exits the labor market. We call a CEO who is hired again in the second period an *old CEO*; and if the firm hires a new CEO in the second period, we call her a *new CEO*. A fired CEO cannot find a job and thus gets a payoff of zero in the second period because her ability is certainly below $\bar{\theta}$, while that of a CEO hired from the market is expected to be $\bar{\theta}$. Depending on its firing decision, at the beginning of the second period, the firm offers a new compensation contract to either the old or a new CEO. If she accepts the offer, she chooses a project, whose probability of failure is represented by r_2, for the second period. Finally, the second-period output y_2 is realized, the CEO is paid w_2, and the firm is dissolved.

As a benchmark, we first characterize the complete information setting in which both the managerial ability and the project choice of the CEOs are observable. Obviously, the firm wants to employ a high-ability CEO, and this CEO has no career concern as there is no risk of being fired. As a result, we can obtain the optimally risky project with probability of failure r_t^* from the joint surplus maximization, $\max_{r_t}\{E[y_t(\theta_H, r_t)]\}$, whose first-order condition yields $2f(r_t) = (1-2r_t)f'(r_t)$, from which we can easily see that the optimally risky project's probability of failure satisfies $r_t^* < 1/2$ in any interior solution.[9] The CEO earns just her reservation payoff in expected terms in the optimal compensation contract, which may involve fixed wage and stock ownership in various combinations.

3. Analysis

In our setting, neither the CEO nor the firm knows the CEO's ability, and only the CEO knows her project's probability of failure. We proceed backward to solve the model. The next subsection analyzes the second period and shows that the CEO, whether new or old, chooses the optimally risky project in the second period because she no longer has any career concern in this period as the firm will be dissolved after that. It also shows that the firm fires the CEO at the end of the first period if and only if, upon observing the first-period output, it believes that the CEO's ability is less than the average ability in the population. The subsection following the next analyzes the first period and shows that choosing an excessively risky project minimizes the probability of being fired when the difference between the abilities is neither too high nor too low. Then, another subsection shows how career concerns affect compensation contract design, followed by a discussion subsection.

3.1. The second period

Because the CEO has no career concern in the second period, the problem that the firm faces is a standard moral hazard problem whose solution leaves no surplus to the CEO, who eventually chooses the optimally risky project with r_2^*. With the optimal contract, the CEO, whether old or new, gets exactly her reservation payoff, $\underline{u}$, in expected terms in this period. The firm and the CEO do not know her ability but rationally expects it to be $\bar{\theta}$ if she is a new CEO. If she is an old CEO, her ability is expected to be $\tilde{\theta} := E[\theta_i | y_1(\theta, r_1)]$, which is her expected ability given the first-period output $y_1(\theta, r_1)$. This leads to the *optimal firing rule*: the firm fires the old CEO and hires a new one in the second period iff $\tilde{\theta} < \bar{\theta}$.[10]

3.2. The first period

This subsection shows the possibility that choosing an excessively risky project may minimize the layoff risk. The optimal firing rule that we derive in the previous subsection says that the firm keeps the old CEO if and only if $\tilde{\theta} \geq \bar{\theta}$. Thus, the CEO has an incentive to influence the market's belief in her ability by her project choice. This is in her best interest if the benefit of minimizing her layoff risk is greater than her loss from compensation due to choosing a project different from the optimally risky project, which depends on the compensation contract she is offered.

[8] We make this assumption to be able to analyze the relationship between layoff risk and managerial risk taking, which requires focusing on a contract renewal period. This is also a standard assumption in career concern models (Gibbons and Murphy, 1992; Hermalin, 1993; Bushman et al., 2010). Hermalin (1993) argues that it is usually infeasible to commit fully to employ the manager at a pre-specified compensation in the future.

[9] The second-order condition, $-4f'(r_t) + f''(r_t)(1-2r_t) \leq 0$, holds for all $r_t < 1/2$.

[10] The implicit assumption here is that the reservation payoff of the CEO, $\underline{u}$, remains unchanged despite the fact that beliefs about her type are updated based on the first-period output. In reality, this reservation payoff may adjust (see the arguments in Holmstrom, 1982, and Gibbons and Murphy, 1992). Following Bushman et al. (2010), we assume for simplicity that there is downward rigidity in the reservation payoffs because managerial ability is firm specific and valuable only within the organization. Nonetheless, choosing an excessively risky project in equilibrium is possible even when reservation payoffs get updated in response to changes in beliefs about managerial ability. In such a case, a manager's future compensation is still an increasing function of the firm's expectation about her ability, and as we show in the text, she can increase the market's expectation about her ability by choosing an excessively risky project.

We first derive the CEO's probability of being fired at the end of the first period, p. Because there are two types (high and low) and two states (good and bad) in the model, there are four possible state realizations for any given project choice. If the CEO chooses the optimally risky project with r_1^*, the firm infers her actual ability upon observing the output, unless by chance outputs coincide for this project choice in any two state realizations.[11] Then, high-ability CEOs are fired with probability zero while low-ability ones are fired with probability one. Given that each type is equally likely in the population, the *ex-ante* probability of being fired for the CEO is 1/2.

Similarly, for other project choices for which the firm infers the actual ability of the CEO upon observing the output (*i.e.*, the cases in which the outputs do not overlap for any state realization of the two types), high-ability CEOs are fired with probability zero while low-ability ones are fired with probability one. Then, once again, the *ex-ante* probability of being fired is 1/2. This means that, given any positive amount of stock ownership, optimally risky project with r_1^* dominates any such project choice, because the CEO faces the same probability of being fired even when she chooses the optimally risky project but receives a higher first-period compensation by doing so.

So, which project does a CEO choose in equilibrium? To answer this, we need to consider three cases in terms of the difference between the abilities. The first case is the case in which even the bad-state output of a high-ability CEO is higher than the good-state output of a low-ability CEO for any project choice, so outputs cannot overlap. This occurs when $\theta_H - f(1) \geq \theta_L + f(1)$ or when the difference between the abilities is high (*i.e.*, $\theta_H - \theta_L \geq 2f(1)$). This is because if this inequality holds, then it should *strictly* hold for all $r_1 \in (0,1)$ as $f(\cdot)$ is an increasing function. In this case, the firm is able to infer the actual ability of a CEO for all possible output realizations, and thus the probability of being fired is independent of the CEO's project choice and equal to 1/2. Then, again, given any positive amount of stock ownership, the optimally risky project with r_1^* dominates all other projects as it involves the same layoff risk with higher first-period compensation. The following lemma records this result.

Lemma 1. (Case 1) *When the difference between the abilities is high (i.e., $\theta_H - \theta_L \geq 2f(1)$), the CEO chooses the optimally risky project with $r_1^* < 1/2$, in equilibrium. Her probability of being fired is 1/2.*

This case represents a situation in which managerial ability is so impactful on the project outcome that a CEO cannot hide her true ability with project selection. For example, one may think of R&D projects in high-tech sectors. In such sectors, managerial ability is crucial in the process of enhancing discoveries, *etc.* Thus, a CEO is simply unable to masquerade her true ability by distorting her project choice.

In the second case, the difference between the abilities is intermediate (*i.e.*, $2f(1/2) \leq \theta_H - \theta_L < 2f(1)$). Now, by choosing the project with $\bar{r}_1 = f^{-1}((\theta_H - \theta_L)/2)$, the CEO is able to overlap the bad-state output when she turns out to be a high-ability CEO with the good-state output when she turns out to be a low-ability CEO (*i.e.*, $\theta_H - f(\bar{r}_1) = \theta_L + f(\bar{r}_1)$). If the firm observes this "overlapped" output level, it is not certain about which type could produce this output.[12] Then, the conditional expectation on the CEO's ability is

$$E[\theta_i | y_1] = (1 - \bar{r}_1)\theta_L + \bar{r}_1 \theta_H. \tag{3}$$

This conditional expectation increases as the project's probability of failure increases. Because $1/2 \leq f^{-1}((\theta_H - \theta_L)/2)$, we know that $\bar{r}_1 \geq 1/2$; this in turn implies $E[\theta_i | y_1] \geq \bar{\theta}$. Therefore, the firm keeps the CEO when it observes this overlapped output. Outputs do not coincide in the remaining state realizations, the CEO's ability is perfectly inferred, and as a result the high-ability ones are retained while the low-ability ones are fired. Consequently, the probability of being fired is $p = \Pr\{\theta = \theta_L\} \times \Pr\{y_1 = \theta_L - f(\bar{r}_1)\} = \bar{r}_1/2$, which is definitely less than 1/2, the probability of being fired when the CEO chooses a different project, and so her ability is inferred in all state realizations.

Choosing $\bar{r}_1$ minimizes the probability of being fired, but it is not automatically an equilibrium. By choosing the excessively risky project rather than the optimally risky project, the CEO is minimizing her layoff risk in the second period, but, she now gets lower compensation in the first period because she did not choose the optimally risky project. For now, we report the project with $\bar{r}_1$ as the project that minimizes the layoff risk, but later we derive the conditions under which choosing that project becomes an equilibrium with linear compensation contracts.

Lemma 2. (Case 2) *When the difference between the abilities is intermediate (i.e., $2f(1/2) \leq \theta_H - \theta_L < 2f(1)$), the probability of failure that minimizes the probability of being fired is equal to*

$$\bar{r}_1 = f^{-1}\left(\frac{\theta_H - \theta_L}{2}\right) \geq \frac{1}{2}, \tag{4}$$

which is associated with an excessively risky project. The CEO's resulting probability of being fired is $\bar{r}_1/2$.

This case represents situations in which both managerial ability and project choice have sufficient impact on the project outcome. In such situations, the firm cannot determine if the resulting outcome is mainly due to the CEO's project choice or her managerial ability. For example, one may think of a portfolio manager who gets together a risky portfolio. When the firm observes a return below the market average, it cannot be sure why the portfolio performed poorly: it could be because the CEO was not competent enough or she actually competently composed a good portfolio but a poor outcome realized (which could happen for any risky project). One can also think of an entrepreneur with a new startup and an investor financing his project. If the entrepreneur has a risky project, upon poor realizations, the investor cannot really tell if the entrepreneur was incompetent or if risks did not realize well.

An important point to note is that the firm does not rehire the old CEO at all times whenever it cannot distinguish her ability. It keeps her in the firm if and only if her expected ability is weakly higher than the average ability, $\bar{\theta}$. When it observes an output level that might be produced by a high-ability CEO with probability $\bar{r}_1 > 1/2$ or by a low-ability CEO with probability $1 - \bar{r}_1$, the firm is not sure of the CEO's true ability, but it rationally expects this output to be produced more likely by a high-ability CEO because $\bar{r}_1 > 1/2$. As a result, after observing such an output, the firm's expectation about the CEO's ability is weakly higher than $\bar{\theta}$, which is the average ability in the managerial market. Thus, when the firm observes such an output level, rehiring the CEO is the best it can do. If it rather replaces her with a new CEO in the second period, the expected ability of this new CEO will be $\bar{\theta}$. Of course, this result is also based on the fact that the firm knows that the CEO, whether old or new, will choose the optimal risky project in the second period since she has no career concerns in that period. Hence, comparing its alternatives, the firm concludes that rehiring the old CEO is the best in an expected-value sense even if it cannot be sure of the CEO's true ability. This process distorts the CEO's project choice since, as an agent with career concerns, she will have the incentive to choose an excessively risky project to hide her true ability.

[11] Because the optimally risky project's probability of failure is less than 1/2, the expectation about the CEO's ability will be below average when outputs coincide for the optimally risky project by chance. Then, the probability of being fired will be higher than 1/2. Then, the CEO chooses a project whose probability of failure is arbitrarily close to the one for the optimally risky project.

[12] We should note that, as Appendix A.4 shows, it would be even easier to hide true type by project choice in a model with more than two state realizations. Thus, the CEO would have more opportunity to engage in influence activity by taking excessive risk in such environments.

Finally, in the third case, the difference between the abilities is low (*i.e.*, $0<\theta_H-\theta_L<2f(1/2)$). Let us first consider the interval $2f(0)<\theta_H-\theta_L<2f(1/2)$. Following the reasoning we have in Case 2, we obtain (3) once again when the CEO chooses to overlap the outputs. However, this time $E[\theta_i|y_1]<\bar{\theta}$ in such a case. She keeps her job only when she turns out to be a high-ability CEO who lands in the good state. Thus, if she chooses a project overlapping the outputs, her probability of being fired is $p=1-\Pr\{\theta=\theta_H\}\times\Pr\{y_1=\theta_H+f(\bar{r}_1)\}=(1+\bar{r}_1)/2$, which is higher than 1/2, the probability of being fired when she chooses a different project. This suggests that in this case, given any positive amount of stock ownership, the optimally risky project with r_1^* dominates all other projects, including the one with $\bar{r}_1$. In the remaining part of the interval of case 3 (*i.e.*, $0<\theta_H-\theta_L\leq 2f(0)$) outputs do not match in any way and thus the probability of being fired cannot be any lower than 1/2, which implies that the CEO chooses the optimally risky project.

Lemma 3. (Case 3) *When the difference between the abilities is low* (*i.e.*, $0<\theta_H-\theta_L<2f(1/2)$), *the CEO chooses the optimally risky project with* $r_1^*<1/2$, *in equilibrium. Her probability of being fired is* 1/2.

This case represents situations in which managerial ability has a low impact on the project outcome. For example, one may think of sectors where the CEO mainly undertakes well-defined procedures. In such cases, the firm knows that the resulting outcome is mainly due to the project type rather than managerial ability. Hence, managerial ability has a little weight on both success and failure outcomes. As a result, the CEO cannot successfully masquerade her managerial ability by employing risky projects.

In sum, the CEO chooses the optimally risky project in equilibrium when the impact of managerial ability on the project outcome is so high or so low that a CEO cannot hide her true ability by her project selection, but when both managerial ability and project choice are sufficiently important to the project outcome, she may choose a project at which the bad-state output of a high-ability CEO coincides with the good-state output of a low-ability CEO. This strategy minimizes her layoff risk. Of course, for this to be an equilibrium, it must also be in her best interest to do so, which we analyze next.

3.3. Contracts

So far, we have shown that career concerns may induce managers to choose excessively risky projects, which enables them to add bias to the market's inferences about their abilities. In this section, we argue that this hypothesis also has interesting implications for compensation contract design. In particular, we show that some prohibited contracts in recent policy frameworks (that are also believed to be increasing managerial risk appetite) may indeed prevent excessive career-concerns-driven risk taking, whereas linear compensation contracts that are in fact allowed (or recommended) by the same policy frameworks do not guarantee optimal risk taking. In other words, given linear contracts, career-concerns may lead CEOs to choose excessively risk projects.

Because excessively risky projects can be chosen only when both managerial ability and project choice have sufficient impact on the project outcome (Case 2), we concentrate on that case in this section. According to Lemma 2, if the CEO chooses the excessively risky project with $\bar{r}_1$, then her probability of being fired is $\bar{r}_1/2$. If she chooses any other project, her probability of being fired is 1/2. Then, she is better off choosing the optimally risky project with r_1^* among all these possible projects because her probability of being fired is still 1/2, but her first-period compensation is higher. This means that the optimally risky project with r_1^* always dominates all other projects, except the excessively risky project with $\bar{r}_1$, given any positive amount of stock ownership. Thus, the CEO's choice in Case 2 is between the projects with $\bar{r}_1$ and r_1^* only.

The firm's maximization problem in the first period is the same as in the second period, except now it includes an additional constraint as well as the standard individual rationality and incentive compatibility constraints. If the firm wants the CEO to choose the optimally risky project, it must compensate for the forgone expected payoff that comes from increased layoff risk by not choosing the project with $\bar{r}_1$. We call this constraint the *career concern constraint*, which is given by

$$E\left[w_1\left(y_1\left(\bar{\theta},r_1^*\right)\right)\right]+\frac{\underline{u}}{2}\geq E\left[w_1\left(y_1\left(\bar{\theta},\bar{r}_1\right)\right)\right]+\frac{(2-\bar{r}_1)\,\underline{u}}{2}\quad \text{if } r_1\neq\bar{r}_1. \tag{CC}$$

The left-hand side of this constraint is the CEO's expected payoff if she chooses the optimally risky project with r_1^*, and the right-hand side is if she chooses the excessively risky project with $\bar{r}_1$. This constraint is derived as follows. If the CEO chooses the excessively risky project with $\bar{r}_1$, her probability of keeping her job in the second period, in which she always obtains her reservation payoff $\underline{u}$, is $(2-\bar{r}_1)/2$. Therefore, her second-period expected payoff is $[(2-\bar{r}_1)\underline{u}]/2$ if she chooses the excessively risky project with $\bar{r}_1$ in the first period. Adding her expected first-period compensation to this term yields the right-hand side of the inequality. If she chooses the optimally risky project with r_1^*, the probability of keeping her job in the second period is 1/2; hence, her expected payoff is $\underline{u}/2$ in the second period. Adding her expected first-period compensation to this term yields the left-hand side of the inequality.

We first analyze linear contracts. The goal of this exercise is to show that career concerns may prevent optimally risky projects to be undertaken under optimal linear contracts. This analysis is of interest because after the 2008–2009 economic and financial crisis, policies left firms with traditional compensation schemes that are mainly linear. Here, we show that career concerns may make it impossible to implement the optimally risky project with such linear compensation schemes. Furthermore, in some cases, the firm may even voluntarily allow the CEO to undertake an excessively risky project.

With a linear compensation contract, the realized compensation of the CEO in period t is given by $w_t(a_t,b_t,y_t(\theta_i,r_t))=a_t+b_ty_t(\theta_i,r_t)$, where $a_t\geq 0$ and $b_t\in[0,1]$ are compensation parameters. If $b_t=0$ and $a_t>0$ in equilibrium, then the contract is a fixed-wage contract, and if $b_t>0$ and $a_t=0$, then it provides stock ownership only. All other combinations involve both a fixed wage and stock ownership simultaneously.[13] Reorganizing the career concern constraint after employing the linear compensation contract assumption gives

$$\left(1-2r_1^*\right)f\left(r_1^*\right)-\left(1-2\bar{r}_1\right)f\left(\bar{r}_1\right)\geq\frac{(1-\bar{r}_1)\,\underline{u}}{2b_1}. \tag{CC$'$}$$

This constraint shows that when the career concern is sufficiently strong, it may be stricter than the incentive compatibility constraint; thus, the solution may involve the excessively risky project with $\bar{r}_1$ chosen by the CEO as a result of the discontinuous jump created by her career concern. The next question asks if choosing the excessively risky project with $\bar{r}_1$ is better than choosing the optimally risky project with r_1^*, which we proceed to answer now.[14]

There are two cases to consider in which excessively risky projects are undertaken in equilibrium. In the first, satisfying the career concern constraint and having the CEO choose the optimally risky project requires giving her stocks more valuable than the firm's output (*i.e.*, $b_1>1$), which the firm cannot afford without incurring a loss.

[13] We do not allow for stock options. If we allow for stock options in addition to stocks, the incentives will be even more skewed toward choosing excessively risky projects (see, *e.g.*, Dong et al., 2010). Moreover, as Murphy (1999) mentions in his well-known review of executive compensation, stock ownership is the most direct way of aligning the preferences of CEOs and shareholders.

[14] A necessary condition is that the firm prefers operating when the CEO chooses the excessively risky project with $\bar{r}_1$, which holds as long as $\underline{u}\leq\theta_L$, which we have already assumed.

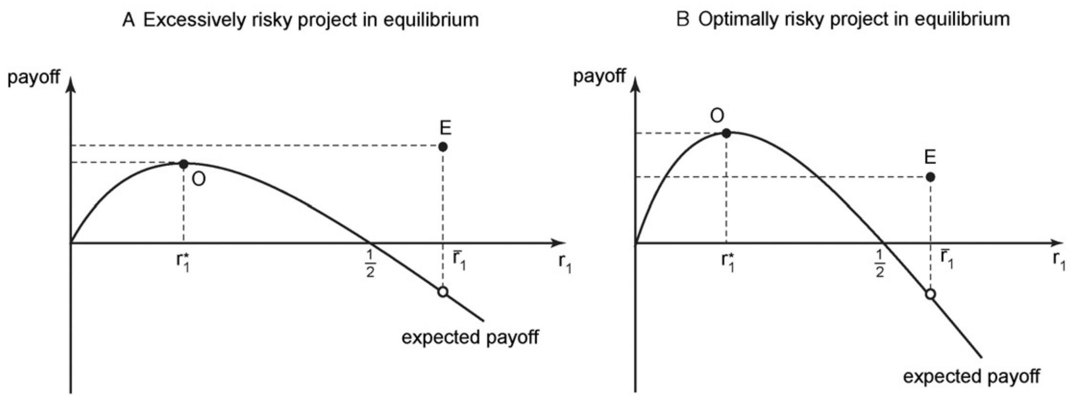

Fig. 2. Choosing an excessively or optimally risky project in equilibrium.

Thus, in such a situation, the firm *involuntarily* allows the excessively risky project to be undertaken in equilibrium. If, therefore,

$$(1-2r_1^*)f(r_1^*)-(1-2\bar{r}_1)f(\bar{r}_1)<\frac{(1-\bar{r}_1)\underline{u}}{2}, \tag{5}$$

then (CC′) is satisfied only when $b_1>1$, which the firm cannot afford without incurring a loss, and thus we get the excessively risky project undertaken in equilibrium. This inequality represents a situation in which the CEO's career benefit from choosing the excessively risky project to hide her ability is higher than the expected return from the project. In such a case, the firm cannot compensate the CEO for her career benefit from choosing the excessively risky project, even if it offers the whole first-period return to her. Note that all terms in this inequality are exogenous. Thus, if it holds, then (CC′) cannot hold, and the excessively risky project becomes imperative.

In the second case in which there is an excessively risky project undertaken in equilibrium, having the CEO choose the optimally risky project is less profitable than letting her choose the excessively risky one. Thus, the firm *voluntarily* allows the excessively risky project to be undertaken in equilibrium.[15] This time, (CC′) is satisfied, which requires providing an amount of stock ownership that satisfies $b_1\geq(\underline{u}(1-\bar{r}_1))/(2[(1-2r_1^*)f(r_1^*)-(1-2\bar{r}_1)f(\bar{r}_1)])$. Hence, the lowest possible stock compensation, $b_1y_1(\theta,r_1^*)$, is given by the following amount:

$$\Omega:=\frac{\underline{u}(1-\bar{r}_1)\left[\bar{\theta}+(1-2r_1^*)f(r_1^*)\right]}{2\left[(1-2r_1^*)f(r_1^*)-(1-2\bar{r}_1)f(\bar{r}_1)\right]}. \tag{6}$$

Then, if $(1-2r_1^*)f(r_1^*)-\Omega<(1-2\bar{r}_1)f(\bar{r}_1)-\underline{u}$, the firm voluntarily allows the CEO to choose the excessively risky project. The left-hand side of this inequality is the profit of the firm when the CEO chooses the optimally risky project, and the right-hand side is that when she chooses the excessively risky one. Reorganizing it yields a condition that looks similar to Eq. (5):

$$(1-2r_1^*)f(r_1^*)-(1-2\bar{r}_1)f(\bar{r}_1)<\Omega-\underline{u}. \tag{7}$$

We summarize the above discussion in the following proposition.

Proposition 1. *(Excessively risky project/two-type) Suppose that the difference between the abilities is intermediate (i.e.,* $2f(1/2)\leq\theta_H-\theta_L<2f(1)$*). The firm involuntarily allows the CEO to choose the excessively risky project if (5) holds. It voluntarily allows the CEO to choose the excessively risky project if (7) holds.*

The crucial point here is that choosing the excessively risky project is possible even under an optimal linear compensation contract. If the excessively risky project is undertaken, the optimal contract is given by $b_1>0$, and $a_1=\underline{u}-b_1[\bar{\theta}+f(\bar{r}_1)(1-2\bar{r}_1)]$. In the involuntary case, as shown in Eq. (5), it is optimal for the CEO to choose the excessively risky project if the expected loss in output that arises from choosing the excessively risky project is less than the career benefit obtained. In the voluntary case, as shown in Eq. (7), the benefit of choosing the optimally risky project is less than the cost of compensating the CEO to let her choose the optimally risky project.

Fig. 2 provides a graphical intuition for choosing the excessively risky project. It shows the CEO's expected payoff *from managerial action* for any r_1 level. Her payoff is increasing up to the optimal probability of failure r_1^* at point O, and then it is ever decreasing unless her career concern kicks in, which is where her payoff discontinuously jumps up to point E. If it is above point O, as in Panel A, then the CEO finds it optimal to choose the excessively risky project. This is because the decrease in her first-period compensation due to not choosing the optimally risky project is less than the career benefit she obtains by minimizing her layoff risk by choosing the excessively risky project. However, if it turns out that point E is below point O, as in Panel B, the CEO chooses the optimally risky project. It is noteworthy that the excessively risky project with $\bar{r}_1$ means choosing a negative NPV project in terms of the return from managerial action. Thus, the project choice alone contributes negatively to the firm output in equilibrium, but the return from managerial ability absorbs the loss.

Now consider a linear contract with a severance payment option. The severance payment is made when the CEO is fired, which is expected to happen with probability 1/2 *ex ante*, if the CEO chooses the optimally risky project. Therefore, where S is the severance payment, the individual rationality constraint in the first period can be written as

$$a_1+b_1(1-2r_1^*)f(r_1^*)+\frac{S}{2}\geq\underline{u}, \tag{8}$$

which will eventually bind. Thus, $S=2[\underline{u}-a_1-b_1(1-2r_1^*)f(r_1^*)]$. Similarly, the career concern constraint becomes

$$b_1(1-2r_1^*)f(r_1^*)+\frac{S}{2}+\frac{\underline{u}}{2}\geq b_1(1-2\bar{r}_1)f(\bar{r}_1)+\frac{(2-\bar{r}_1)\underline{u}}{2}\quad \text{if } r_1\neq\bar{r}_1. \tag{9}$$

Intuitively, this contract is able to implement the optimally risky project because it diminishes the CEO's "fear" of being fired by providing severance payment. Substituting for S in (9) shows that a compensation of $a_1+b_1(1-2\bar{r}_1)f(\bar{r}_1)=[(1+\bar{r}_1)\underline{u}]/2$ satisfies all constraints including the incentive compatibility constraint and achieves the optimally risky project. This contract is optimal because there is no other contract that could yield higher payoffs to the shareholders.

[15] In a related vein, Bebchuk and Spamann (2010) also mention that even after eliminating the excessive risk from the perspective of the common shareholders in banks, there may still remain excessive risk from the perspective of society because common shareholders are not concerned about preferred shareholders, bondholders, depositors, and taxpayers. We get our result for a different reason because we do not have any of these third parties in the model.

Now consider a bonus contract. Suppose that the firm promises to pay a fixed bonus equal to $\underline{u}$ if the CEO obtains $\theta_H+f(r_1^*)$, θ_H-$f(r_1^*)$, $\theta_L+f(r_1^*)$, or θ_L-$f(r_1^*)$ and zero otherwise. The CEO is still fired if her assessed ability is below average. It is immediately clear that this contract implements the optimally risky project.[16] It is also one of the least costly ways of implementing the first best because it pays nothing more than what is required to satisfy the individual rationality constraint.

What is more interesting is that the bonus contract implements the optimally risky project even when the CEO can sabotage output, which requires some detailed treatment. When sabotaging output is possible, the CEO chooses the excessively risky project with $\mathring{r}_1$, which satisfies $\theta_L+f(\mathring{r}_1)=\theta_H$-$f(r_1^*)$. The probability of failure $\mathring{r}_1$ is higher than $\bar{r}_1$ defined in Eq. (4). If the CEO obtains $\theta_H+f(\mathring{r}_1)$, she can sabotage output (perhaps by selling it at too low a price) and make it appear as if she chose the optimally risky project with r_1^*. In this case, she not only gets the bonus in the first period but also keeps her job in the second period. If she obtains θ_H-$f(\mathring{r}_1)$, then she cannot get the bonus, but she keeps her job in the second period because the firm infers that she is a high-ability CEO. If she obtains $\theta_L+f(\mathring{r}_1)$, the firm cannot be sure if she is a low-ability CEO in the good state or a high-ability CEO in the bad state. However, because $\mathring{r}_1>\bar{r}_1$, the firm expects her ability to be higher than $\bar{\theta}$ and thus keeps her in the second period. Moreover, because $\theta_L+f(\mathring{r}_1)=\theta_H$-$f(r_1^*)$, it pays the bonus. Finally, if she obtains θ_L-$f(\mathring{r}_1)$, she cannot get the bonus and she is fired for sure. Consequently, her expected two-period benefit from choosing the excessively risky project with $\mathring{r}_1$ is $(1-\mathring{r}_1)\underline{u}+(2-\mathring{r}_1)\underline{u}/2$, while that from choosing the optimally risky project is $\underline{u}+\underline{u}/2$, which is higher. Thus, whether the CEO can sabotage output or not, the bonus contract implements the optimally risky project.

The optimality of bonuses and severance payment is of high interest because the common view in the media is that these contracts do trigger excessive risk taking, but this result says that they can prevent excessive risk taking due to career concerns. This view has an impact in the recent regulatory framework, too. For example, the American Recovery and Reinvestment Act prohibits TARP recipients from paying or accruing any bonus or severance payment, but allows only long-term restricted stocks. Our setting shows that this may generate adverse effects due to career concerns. It is true that our setting is simple and stylistic but it is also true that the mechanism we talk about (namely the motivation for choosing projects that minimize layoff risk) is still at work even in relatively more complex environments with idiosyncrasies.

3.4. Discussion

We close this section with some comments on the structure of the model and robustness of the results under different specifications.

The fact that there is just one point jumping up discontinuously as a result of career concern in Fig. 2 is an artifact of our two-type specification. Nevertheless, as we show in Section 4, the same mechanism works when we have a continuum of types, in which case there is a mass of points jumping up and their local maximizer gives us the new $\bar{r}_1$. If it is also the global maximizer (as in Panel A of Fig. 2), then the excessively risky project is chosen in equilibrium. Otherwise, the CEO chooses the optimally risky project (as in Panel B of Fig. 2).

Our main results are independent of bilateral risk neutrality. First, unlike the bilateral risk-neutrality case of a standard hidden-action problem, the career concern can be so strong that even providing the whole output of the first period to the CEO may not prevent her from choosing the excessively risky project. The analogy would be a young fund manager who may choose excessively risky investments even in managing her own portfolio as a result of her concern that if she does not perform well now, she might not receive outside funds in the future. Second, as shown in Appendix A.1, the results remain qualitatively the same even when the CEO is risk averse.

The CEO's possibility of affecting a firing decision with her project choice implies behavior consistent with behavioral finance's concept of CEO overconfidence. This literature is based on the hypothesis that many CEOs tend to think that they are better than average (Malmendier and Tate, 2005), and this leads them to be more likely to attribute good outcomes to their managerial ability or style. Hence, the literature argues that overconfident managers overestimate their abilities, so their investment decisions are riskier than what is ideal (Adam et al., 2015). Another behavioral source of risk taking is optimism (Wang et al., 2013). In our setting, a “rational” CEO chooses an excessively risky project not because she is overestimating her ability, but to ensure that the market overestimates her ability.

CEOs do not have career concerns in the second period because the firm is dissolved at the end of this period. Thus, they choose the optimally risky projects in this period while they may choose excessively risky projects in the first period. Hence, with linear contracts, we predict that the preferences of CEOs who are closer to the end of their careers to be more in line with the preferences of the shareholders. Results in the literature about changes in managers' behavior as their careers evolve are somewhat mixed. Chevalier and Ellison (1999) analyze career concerns of mutual fund managers and find that younger managers take on less unsystematic risk than their older counterparts. In contrast, with mutual fund managers who incur more risk over time, Boyson (2003) and Li, Zhang, and Zhao (2011) provide evidence on hedge fund managers taking on less risk as their career evolves.[17] Hong et al. (2000) and Lamont (2002) find that younger analysts and forecasters (who have stronger career concerns than their older counterparts) herd more compared to their older counterparts. Graham (1999) and Li (2002) provide evidence for the opposite. Finally, Li, Low, and Makhija (2011) and Serfling (2014) examine real investment activities of managers and report that younger managers follow more aggressive investment strategies.

4. Continuum of types

In this section, we extend the line of reasoning we derived from the two-type analysis to a continuum of CEO types. Our analysis also predicts an inverse U-shaped relationship between unobservable ability and the probability of being fired: while the above-average CEOs do not face any layoff risk, among the below-average CEOs, higher-ability ones are certainly fired while lower-ability ones are fired only with some probability.

The optimal firing rule, derived in Section 3.1, and the optimal second-period compensation contract, which gives the CEO her reservation payoff in the second period, continue to apply in this section. Thus, as in the two-type case, the basic mechanism of the model works as follows. Given that the CEO is paid her reservation payoff in the second period, she trades off the decrease in her layoff risk in the second period by choosing an excessively risky project in the first period for the increase in her expected compensation (in the first period) by choosing the optimally risky project. With linear contracts, there are robust instances in which the former effect dominates the latter in expected payoff,

[16] One can generalize this bonus contract further: the firm could pay the bonus if the CEO produces an output in the range $[\theta_L$-$f(r_1^*),\theta_H+f(r_1^*)]$. That is, the firm rewards the CEO only if she produces intermediate levels of output. In that case, the CEO never chooses a risk level higher than r_1^* and be indifferent between any other risk choices, in which case she will choose the optimally risky project according to our tie-breaking convention.

[17] Boyson (2003) argues that the contradictory conclusions of these empirical studies may depend on different incentives provided in various sectors to overcome the effects of career concerns. She also mentions that career concerns of managers in hedge funds are much stronger compared to those in mutual funds: “... failed hedge fund managers rarely start new hedge funds. By contrast, about 67% of failed or terminated mutual fund managers remain in their industry.” Moreover, she argues that agency costs are significantly lower in hedge funds than in mutual funds, which makes the effects of career concerns relatively more important in the former.

and thus we get an excessively risky project chosen in equilibrium, either by the firm's consent or against its will.

We shall now talk about "the range of abilities" rather than "the difference between the two abilities," as there is now a continuum of abilities rather than just two. In particular, we assume that managerial abilities are uniformly distributed on the interval $[\theta_L,\theta_H]$ with a mean of $\bar{\theta}$. Just as in the two-type world, it turns out that there are three possible cases to consider in terms of the range of abilities (high, intermediate, and low), and we find that excessively risky projects undertaken in equilibrium only for the intermediate range of abilities. For brevity, we state only the results for the other two cases in the following lemma, leaving the detailed analysis to Appendix A.2.

Lemma 4. (Cases 1 and 3) *When there is a high (i.e., θ_H-$\theta_L \geq 4f(1)$) or low (i.e., θ_H-$\theta_L < 2f(1/2)$) range of abilities in the CEO labor market, the CEO chooses the optimally risky project with $r_1^* < 1/2$, in equilibrium. Her probability of being fired is 1/2.*

Now, consider Case 2 in which there is an intermediate range of abilities in the CEO labor market (*i.e.*, $2f(1/2) \leq \theta_H$-$\theta_L < 4f(1)$). This time, we proceed by the guess-and-verify method. We make the *educated* guess that the CEO chooses the project with $\bar{r}_1$ such that

$$4\bar{r}_1 f(\bar{r}_1) = \theta_H - \theta_L \tag{10}$$

is satisfied. This is the project choice that guarantees that even the worst type is able to overlap her good-state output with the bad-state output of an above-average CEO. The subsequent analysis proceeds as follows. Assuming the project with $\bar{r}_1$ to be the equilibrium project choice, we first derive the probability of being fired. Then, in Appendix A.3, we prove that this project is indeed the one that minimizes the probability of being fired. Finally, we show that minimizing the probability of being fired can indeed be an equilibrium under certain conditions when linear contracts are employed by the firm.

Fig. 3 shows the partition of CEOs on the ability distribution. The partitions are denoted by *A*, *B*, *C*, and *D*. The ability range of this case guarantees that, given $\bar{r}_1$, there is a θ''-type whose bad-state output coincides with the good-state output of the worst type, θ_L, and the firm's expectation between these two types is exactly $\bar{\theta}$ (that is, $\theta_L + f(\bar{r}_1) = \theta'' - f(\bar{r}_1)$ and $(1-\bar{r}_1)\theta_L + \bar{r}_1\theta'' = \bar{\theta}$). They also guarantee that there is a θ'-type whose good-state output coincides with the bad-state output of the best type, θ_H (that is, $\theta' + f(\bar{r}_1) = \theta_H - f(\bar{r}_1)$). Of course, the expectation between these two types must be higher than $\bar{\theta}$.

Fig. 3 provides the distance between the particular types mentioned in the previous paragraph. Eq. (10) implies that the distance between θ_L and $\bar{\theta}$ and the distance between $\bar{\theta}$ and θ_H are both $2\bar{r}_1 f(\bar{r}_1)$ because $\bar{\theta}$ is the mean of the uniform distribution. Moreover, from the specifications provided in the previous paragraph, one can easily find that the distance between $\bar{\theta}$ and θ'' is $2(1-\bar{r}_1)f(\bar{r}_1)$. Thus, the distance between θ'' and θ_H is $2(2\bar{r}_1 - 1)f(\bar{r}_1)$, which is also the distance between θ_L and θ'. Consequently, the mass in *A* is equal to the mass in *D* and the mass in *B* is equal to the mass in *C*. Note also that $\bar{r}_1$ is associated with an excessively risky project because it is higher than 1/2 as a result of the fact that $4\bar{r}_1 f(\bar{r}_1) > 2f(1/2)$ in this case.

We can now derive the probability of being fired in each partition. Because the expectation between θ_L and θ'' is exactly $\bar{\theta}$ at $\bar{r}_1$, the expectation about the ability of a CEO in *A* must be higher than $\bar{\theta}$ when she obtains the good-state output. Thus, she is rehired in such an output realization. If she obtains the bad-state output, her ability is inferred and she is fired for certain. Thus, the probability of being fired for a CEO in this partition is $\bar{r}_1$. Next, consider a CEO in *B*. With the given project choice, she is not able to overlap her good-state output with the bad-state output of any existent type and yet her ability is less than $\bar{\theta}$; thus, she is certainly fired in any output realization.

Now consider a CEO in *C*. Her ability is inferred to be above $\bar{\theta}$ because there is no CEO below $\bar{\theta}$ overlapping her good-state output with the bad-state output of this CEO. Thus, she is rehired for certain. Finally, the bad-state output of a CEO in *D* coincides with the good-state output of a CEO in *A*, and thus she is rehired in her bad state. She is rehired for certain in her good state as well because her output in that state does not coincide with the bad-state output of any existent type above her. Hence, the probability of being fired is zero for a CEO in this partition.

Given the above analysis, the overall probability of being fired is given by $p = \bar{r}_1 \times \Pr\{\theta \in A\} + 1 \times \Pr\{\theta \in B\} + 0 \times \Pr\{\theta \in C\} + 0 \times \Pr\{\theta \in D\}$, or

$$p = \bar{r}_1 \frac{2(2\bar{r}_1 - 1)f(\bar{r}_1)}{4\bar{r}_1 f(\bar{r}_1)} + \frac{2(1-\bar{r}_1)f(\bar{r}_1)}{4\bar{r}_1 f(\bar{r}_1)} = \frac{2\bar{r}_1^2 - 2\bar{r}_1 + 1}{2\bar{r}_1}, \tag{11}$$

which is definitely less than 1/2 because $\bar{r}_1 > 1/2$. What remains to be shown is that the project with $\bar{r}_1$ is indeed the one that minimizes the probability of being fired, which we prove in Appendix A.3 by comparing the *p* value in Eq. (11) with the ones that stem from other possible project choices. Thus, we have the following lemma.

Lemma 5. (Case 2) *When there is an intermediate range of abilities in the CEO labor market (i.e., $2f(1/2) \leq \theta_H$-$\theta_L < 4f(1)$), the probability of failure level that minimizes the probability of being fired solves (10), which is associated with an excessively risky project. The resulting probability of being fired is given by (11).*

In the rest of this section, we look for the equilibrium project choice in Case 2. For the reasons explained before, we restrict attention only to linear contracts. However, one should keep in mind that as in the two-type case, bonus contracts or contracts with severance payment option may implement the optimally risky project even in the continuum of types. As in the two-type case, the probability of failure of a project that solves Eq. (10) is not automatically an equilibrium. For that to be an equilibrium, minimizing the probability of being fired must be in the best interest of the CEO. This may be the case when the CEO's compensation benefit by choosing the optimally risky project is dominated in expected payoff by the career benefit she derives by choosing the excessively risky project and hence minimizing her probability of being fired. However, unlike the two-type case in which choosing the

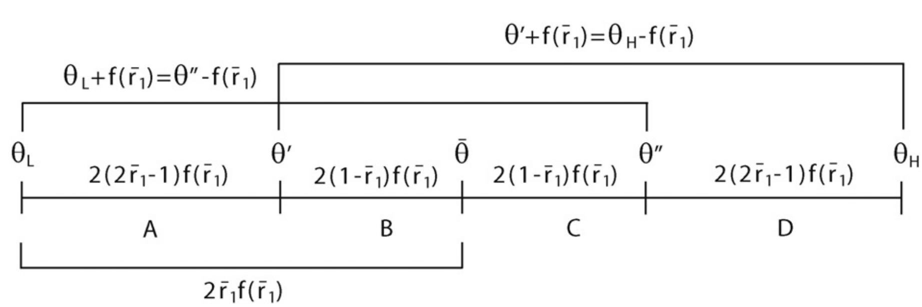

Fig. 3. The partition of CEO types in Case 2.

excessively risky project with $\bar{r}_1$ is the only serious alternative against the optimally risky project, here the CEO may potentially choose a project different from the one minimizing the probability of being fired in equilibrium.

As shown in Appendix A.3, choosing a project with a probability of failure higher than $\bar{r}_1$, satisfying $f(r_1)\in(f(\bar{r}_1), 2\bar{r}_1 f(\bar{r}_1))$, results in a higher probability of being fired than choosing the project with $\bar{r}_1$. At the same time, because $\bar{r}_1$ is closer to r_1^*, the first-period compensation is going to be higher with any amount of stock-based compensation. Thus, in expected payoff, choosing the project with $\bar{r}_1$ still dominates choosing any project satisfying $f(r_1)\in(f(\bar{r}_1), 2\bar{r}_1 f(\bar{r}_1))$. However, if the CEO chooses a project satisfying $f(r_1)\in(\bar{r}_1 f(\bar{r}_1), f(\bar{r}_1))$, as shown in the appendix, the probability of being fired is still higher than choosing the project with $\bar{r}_1$, yet this time the first-period compensation is going to be higher with any amount of stock-based compensation because this project's probability of failure is closer to r_1^*. As a result, the CEO may prefer to trade off the increased probability of being fired for greater first-period compensation. Any such project chosen in equilibrium is still excessively risky although it does not minimize the layoff risk. Therefore, unlike the two-type case, there are now many excessively risky projects in an interval that may be chosen in equilibrium rather than just one such project (*i.e.*, point E of Fig. 2). The local maximizer of this interval is the most serious candidate against the optimally risky project, and in fact, if it is also the global maximizer, it is the equilibrium.

We now turn to the derivation of the optimal linear contract. The increase in the probability of being rehired in the second period by choosing the project with $\bar{r}_1$ in the first period is now given by

$$(1-p(\bar{r}_1)) - (1-p(r_1^*)) = \frac{3\bar{r}_1 - 2\bar{r}_1^2 - 1}{2\bar{r}_1}. \tag{12}$$

Thus, the new career concern constraint with $\bar{r}_1$ is given by

$$E[a_1 + b_1 y_1(\bar{\theta}, r_1)] - E[a_1 + b_1 y_1(\bar{\theta}, \bar{r}_1)] \geq \frac{(3\bar{r}_1 - 2\bar{r}_1^2 - 1)\,\underline{u}}{2\bar{r}_1} \quad \text{if } f(r_1)\notin(\bar{r}_1 f(\bar{r}_1), f(\bar{r}_1)), \tag{CC}$$

where the left-hand side is the extra compensation that the firm must provide to the CEO for her expected forgone career benefit by choosing a project with r_1 such that $f(r_1)\notin(\bar{r}_1 f(\bar{r}_1), f(\bar{r}_1))$, which is shown on the right-hand side. Apart from this change in the career concern constraint, the maximization problem of the firm and its solution remain qualitatively the same. Thus, we provide the following proposition without a proof.

Proposition 2. (*Excessively risky project/continuum*) *Suppose there is an intermediate range of abilities in the CEO labor market* (*i.e.*, $2f(1/2)\leq\theta_H-\theta_L<4f(1)$). *The firm involuntarily allows the CEO to choose the excessively risky project if*

$$f(r_1^*)(1-2r_1^*) - f(\bar{r}_1)(1-2\bar{r}_1) < \frac{(3\bar{r}_1 - 2\bar{r}_1^2 - 1)\,\underline{u}}{2\bar{r}_1}. \tag{13}$$

It voluntarily allows the CEO to choose the excessively risky project if

$$f(r_1^*)(1-2r_1^*) - f(\bar{r}_1)(1-2\bar{r}_1) < \frac{\left(3\bar{r}_1 - 2\bar{r}_1^2 - 1\right)\left[f(r_1^*)(1-2r_1^*) + \bar{\theta}\right]\underline{u}}{2\bar{r}_1\left[f(r_1^*)(1-2r_1^*) - f(\bar{r}_1)(1-2\bar{r}_1)\right]} - \underline{u}. \tag{14}$$

In both cases, the equilibrium project choice with r_1 *satisfies* $f(r_1)\in(\bar{r}_1 f(\bar{r}_1), f(\bar{r}_1)]$, *where* $\bar{r}_1$ *is defined by (10).*

Eqs. (13) and (14) are respectively the counterparts of Eqs. (5) and (7) in the continuum of types case. Note that if these equations hold for the project with probability of failure $\bar{r}_1$, and if another project whose probability of failure satisfying $f(r_1)\in(\bar{r}_1 f(\bar{r}_1), f(\bar{r}_1)]$ dominates the project with $\bar{r}_1$, then these conditions hold for that project as well. Thus, the proposition applies for any project in that interval, not just for the one with $\bar{r}_1$. The intuitions for Eqs. (13) and (14) are the same as those provided for Proposition 1. Eq. (13) says that the career benefit the CEO derives from choosing the excessively risky project is higher than the compensation benefit she derives in the first period by choosing the optimally risky project, even when she is offered the whole first-period return. Thus, the firm cannot design a linear compensation contract that implements the optimally risky project, even if it wants to do so. Eq. (14) gives the condition under which the expected profit of the firm is higher with the excessively risky project than that with the optimally risky one. As in the two-type case, one can easily see that none of our results stems from our assumption that the CEO is risk neutral.

So far, we have shown that all results of the two-type case extend to the continuum of types case. This case also provides an important prediction that we do not have in the two-type case. Consider a CEO whose ability is below $\bar{\theta}$ in Fig. 3. If she is in *A*, then she is able to overlap her good-state output with the bad-state output of an above-average CEO; thus, she is not fired in such a state. However, if she is in *B*, then she is not able to overlap her good-state output with the bad-state output of any existent type in the ability distribution. As a result, a CEO in *B* is fired for certain whereas one in *A* is fired only with probability r_1, which means that, among those who are below average, a worse type is less likely to be fired than a better type. However, those who are in *C* and *D*, all of whom are above average, are not fired in any case. Thus, there is an inverse U-shaped relationship between unobserved ability and the probability of being fired.

Proposition 3. (*Ability and layoff risk*) *There is an inverse U-shaped relationship between the unobserved ability and the probability of being fired.*

The intuition for this result is as follows. By choosing a riskier project, a lower-ability CEO can disguise her type more convincingly because her good-state output is not going to be very high anyway. Hence, she has some chance of successfully substituting the return from managerial ability with the return from managerial action. The firm is skeptical to some extent, but it is not 100% sure if the CEO is below average ability or not. A higher-ability (but still below-average) CEO is also able to do the same substitution, but this time, the observed output is so high that the firm believes there is no way this CEO is above average ability. That is, if the CEO ends up with an unbelievably high output, then the firm is certain that this output is coming from a lucky below-average type who gambled and thus fires her without hesitation. In other words, she has to appear to be too-good-to-be-true in order to successfully cover her type in that range.

5. Conclusion

The project choice of a CEO who is concerned with her career may differ from the project choice that maximizes the shareholders' return or society's social return. The question is in what way the project choice will be distorted. The managerial conservatism literature suggests that a top manager is likely to be less entrepreneurial and take too little risk because she would like to oversee the firm with the least amount of problems and the minimum risk of obtaining bad states; thus, this literature advises shareholders to design compensation contracts that encourage the manager to take higher risk.

In this paper, we show that layoff risk may lead CEOs to employ excessively risky projects. The existence of limited liability or convex compensation schemes are the two common explanations for excessive risk taking. Thus, to highlight the new channel we offer in this paper, we allow for linear combinations of fixed-wage and stock compensation and do not assume limited liability. We show that optimal linear compensation contracts may not be helpful in preventing CEOs from choosing excessively risky projects. Because a CEO is replaced by a new CEO if her expected ability is below average, in trying to limit her layoff risk, she chooses a project that can improve the market's belief about her ability. In our setting, this can be achieved by choosing an excessively risky project when both managerial ability and project choice have sufficient impact on the project outcome. The CEO chooses the project with which the good-state output when she turns out to be a low-ability type coincides with the bad-state output when she turns out to be a high-ability type.

While the firm foresees that the CEO will choose an excessively risky project, once it observes the overlapped output level, it has to statistically infer that this is more likely to be the output of a high-ability CEO who is in the bad state than the output of a low-ability CEO in the good state, as the bad state is more likely with an excessively risky project. By following this strategy, the CEO makes the firm unable to determine if a poor outcome resulted from her incompetency for the position or negative risk realization. Although the firm is not fooled by the actions of the CEO, its expectation about the CEO's ability is that it is above average, despite the fact that each type is equally likely in the population. We also show that, unlike linear contracts, bonus contracts or linear compensation contracts with severance payment option may implement the optimally risky project. Thus, we question the movement toward linear contracts in the practice of compensation regulation after the deep economic and financial crisis of 2008–2009.

Whether there is excessive or too little risk in the market is obviously a sector-specific question. A president of a university may opt for a quiet life while a surgeon may push for surgery even though it is not entirely necessary. We believe that the banking industry, or the financial sector in general, is an example of excessive risk taking. The structure of financial markets is so complicated that shareholders cannot entirely and precisely evaluate whether the observed return is due to the CEO's ability or to pure luck. Using financial derivatives, CEOs can simply gamble on anything and possibly improve the market's belief on their ability. For one reason or another, there is a mismatch between the preferences of shareholders and CEOs, and we believe that there always will be.

Appendix A. Supplementary material

Supplementary material to this article can be found online at http://dx.doi.org/10.1016/j.econmod.2016.03.023.

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